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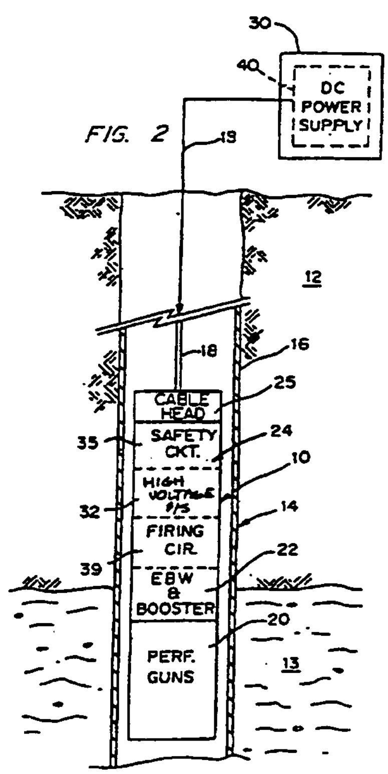
(54) EBW perforating gun system

(57) An EBW detonation circuit system is disclosed for use in connection with a conventional perforating gun system, including a source (40) of DC power at the surface and supplied to the perforating gun system through a wireline cable interconnected therebetween. The EBW safety detonation system includes an electronic safety circuit module (35) interposed between the DC power supply (40) at the surface and a downhole high voltage power supply (32) for preventing unintentional activation of the high voltage power supply (32) by stray AC/RF and DC voltages present at the wellsite. The high voltage power supply generates a DC firing voltage capable of detonating an EBW detonator through a firing circuit (39) for receiving the DC firing voltage from the high voltage power supply (32) for application to the EBW detonator.

FIG. 2



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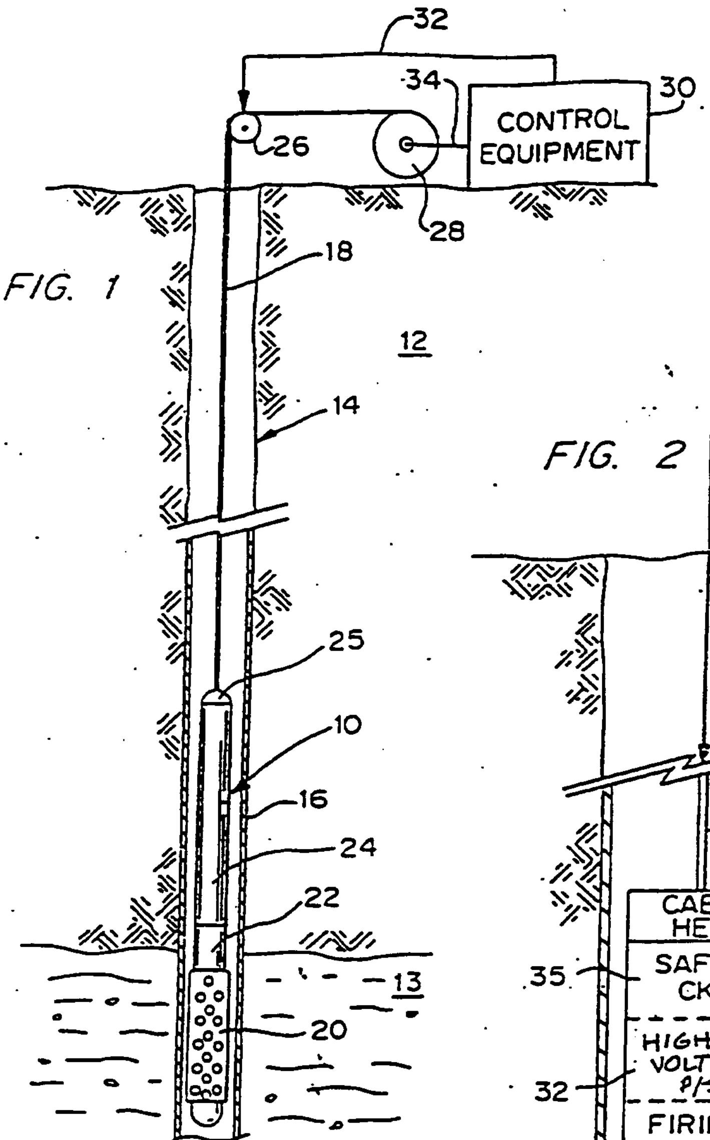
32
34
30
CONTROL EQUIPMENT
26
28
18
12
14
25
10
16
24
22
13
20

FIG. 1

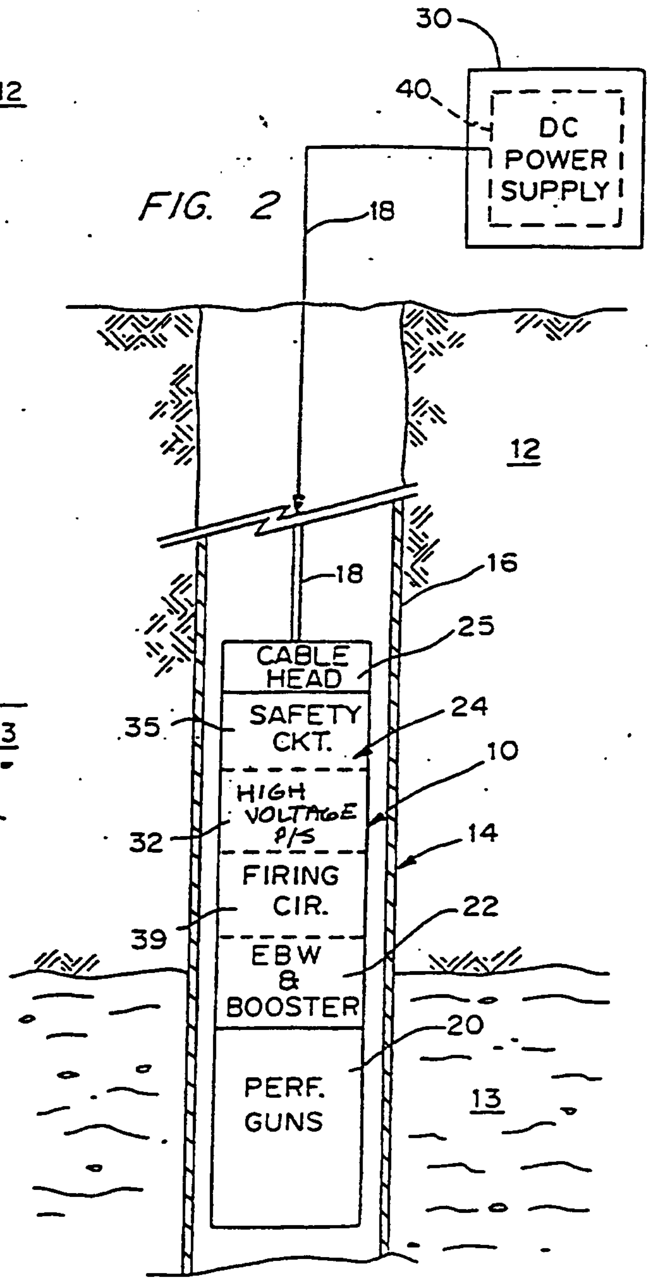
30
40
DC POWER SUPPLY
18
12
16
18
25
CABLE HEAD
35
SAFETY CKT.
24
10
HIGH VOLTAGE P/S
32
14
FIRING CIR.
39
22
EBW & BOOSTER
20
PERF. GUNS
13

FIG. 2

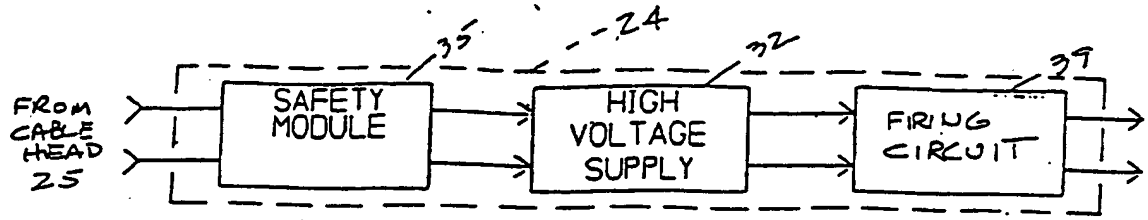

FIG.3

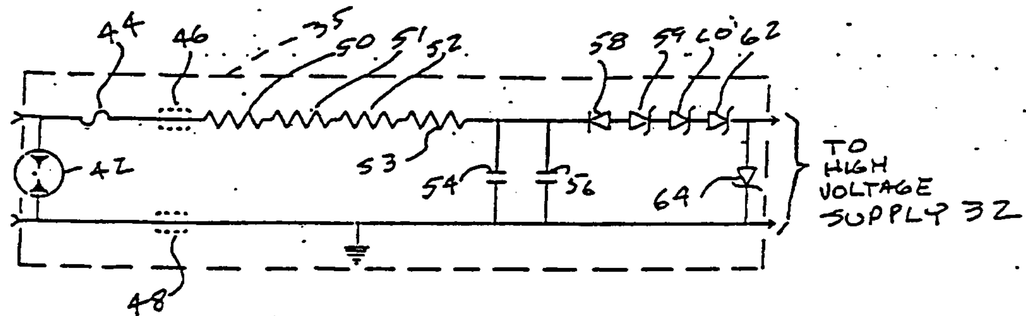

FIG.4

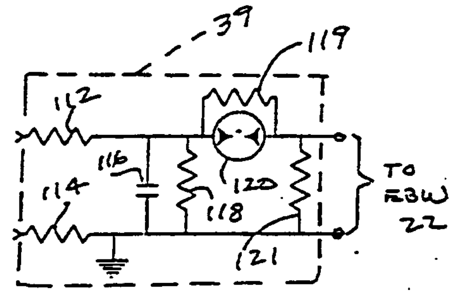

FIG.6

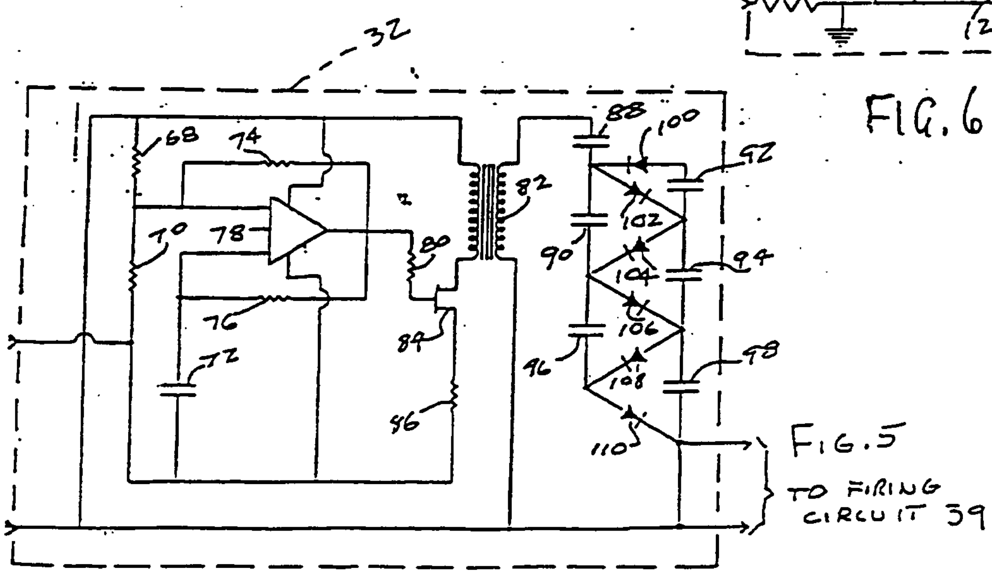

FIG.5

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EBW PERFORATING GUN SYSTEM

This invention relates to perforating gun systems and more particularly to Exploding Bridgewire (EBW) detonators and safe detonation systems for firing such EBW detonators.

A conventional electric detonator of the kind in general use by wireline service companies for use in oil and gas well perforating activities typically contains an electrical bridgewire embedded in an ignition mix, plus a primer charge and a base charge.

The main drawbacks of such electric detonators are:

1. They contain sensitive primary explosives and must be handled carefully to avoid accidental initiation by mechanical impact; and

2. They are easily fired electrically, requiring only the application of 0.5 A or less for a few milliseconds so they are particularly susceptible to any source that could provide this power accidentally, such as electric welding equipment, radio transmitters, cathodic protection systems and faulty rig machinery and equipment. To protect against such spurious electrical power, all possible equipment and machines that could produce such stray power often have to be shut down for extended periods, and the wellhead and rig structure monitored for stray voltages.

By contrast, EBW detonators contain no primary explosive, which makes them insensitive to initiation by mechanical impact and therefore safer to handle than conventional detonators. In addition, they are immune to initiation by the external power sources usually found on the well or rig site. However, to fire an EBW detonator successfully requires the use of a specialized electronic circuit that can generate a high voltage, high current pulse. However, that electronic

circuit could still pick up spurious AC, radio frequency (RF) and DC voltages from the many rig sources named above, including lightning strikes, which could therefore accidentally cause the EBW detonator to be fired.

According to the present invention, there is provided an EBW safety detonation system, for use in connection with a perforating gun system, including a source of DC power at the surface and supplied to the perforating gun system though a wireline cable interconnected thereto, the system comprising a high voltage power supply for generating a DC firing voltage capable of detonating an EBW detonator, an electronic safety circuit, arranged to be interposed between DC power supply at the surface and said high voltage power supply, for preventing unintentional activation of the power supply by stray AC/RF and DC voltages present at the wellsite, and a firing circuit for receiving said DC firing voltage from said high voltage power supply for application to the EBW detonator.

The present invention can be so implemented as to remedy the problems of the prior art by providing an EBW detonation circuit system for use in connection with a conventional perforating gun system, including a source of DC power at the surface and supplied to the perforating gun system through a wireline cable interconnected thereto, without requiring any additional perforating gun hardware.

For a better understanding of the invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

Fig. 1 is an illustrative drawing showing a wireline perforating tool disposed in a wellbore and utilizing an expendable EBW firing module;

Fig. 2 is a block diagram showing the major

assemblies of the wireline perforating tool utilizing the expendable EBW firing module;

Fig. 3 is a block schematic of a safety EBW detonation circuit of the EBW module of Fig. 2;

Fig. 4 is a detailed schematic diagram of the preferred embodiment of a safety circuit module for the EBW detonation circuit of Fig. 3;

Fig. 5 is a detailed schematic diagram of a preferred embodiment of a high voltage power supply module of the EBW detonation circuit of Fig. 3; and

Fig. 6 is a detailed schematic diagram of a preferred embodiment of a firing circuit module of the EBW firing circuit of Fig. 3.

Referring to Figs. 1 and 2, a wireline perforating gun system 10, including EBW detonation circuit system 24, is shown disposed in a borehole 14 that has been drilled in earth formation 12. The perforating gun tool 10 is shown spaced adjacent steel casing 16 that has been set in the borehole 14 adjacent a formation of interest 13. The tool 10 is supported by a conventional single- or multi-conductor wireline cable 18 that travels over a sheave 26 and is spooled onto a winch drum 28. The perforating tool 10 is raised and lowered in the borehole 14 by the action of the cable drum 28 and the "spooling out" of the cable 18 to lower the gun system 10 in the borehole, or the "spooling in" of cable 18 to raise the perforating gun system in the borehole 14. Depth measurements are made from the travel of the wireline cable 18 as it passes over the sheave 26 and communicated to the surface control equipment 30 via cable or conductor 32. Electrical power for operating the perforating gun system 10, including the necessary control signals for firing the tool, are applied through the cable 18 from the control equipment 30.

The perforating gun system 10 includes a

perforating gun section 20, an EBW detonator and booster section 22, an expendable EBW detonating circuit system 24 cooperating with the EBW section 22, and a cablehead 25 interconnected to the cable 18 and the control panel 30. As more particularly shown in Figs. 2 and 3, the expendable EBW detonating circuit system 24 comprises a safety circuit module 35, a high voltage power supply module 37 and a firing circuit module 39. The EBW detonation circuit system 24 receives DC power for operating the EBW and booster section 22 for firing the perforating gun system 20 from a DC power supply 40 disposed in the surface control equipment 30 transmitted via the single-or multiconductor cable 18 and cablehead 25.

Referring now to Figs. 1-6, the operation of the preferred embodiment of the EBW detonation circuit system 24 will be described in detail. DC electrical power is applied from the DC power supply 40 in the surface equipment 30 through the cable 18 and cablehead 25 to input of the safety circuit module. The DC power (200-220 VDC) is applied to one side of a surge voltage protector (SVP) 42, rated at a predetermined breakdown voltage substantially higher than the input voltage from the power supply 40. The SVP protects against accidental energizing of the power supply 32 and the firing circuit 39 such as may be caused by large stray DC voltages that may be induced in the circuit, such as may be caused by a lighting strike near to the perforating gun system 10 or other major DC power interferences at the wellsite. In the event that a voltage equal to or greater than the breakdown voltage of SVP 42 is applied to the input of the EBW detonation circuit system 24, the SVP 42 conducts and connects the input of circuit 35 directly to ground potential (the perforating gun housing).

The 200 VDC applied across the SVP 42 is also

applied across the resistor and capacitor bank comprising the series connected resistors 50, 51, 52 and 53 and a parallel connected capacitor bank 54 and 56. The capacitor bank 54 and 56 appears as an open circuit to DC power, but it offers a low impedance path to start any RF/AC applied as an input to the circuit 35 to ground. While the capacitor bank 54 and 56 is shown comprising several capacitors in parallel, the capacitor bank could be replaced with a single capacitor that is rated the same as the combined capacitance of the bank 54 and 56. Similarly, the resistor bank 50 to 53 could be replaced with a single resistor that is rated the same as the combined resistance of the resistance bank 50 to 53. Any significant stray RF or AC voltage will cause a current in excess of the rating of fuse 44 for blowing the fuse and disable the input to the safety circuit module 35, thus preventing activation of the high voltage power supply module 32. Such AC and/or RF inputs might be caused by adjacent power generating machinery, radio transmitters, radar equipment, faulty rig wiring or equipment or other like sources that may be present at the well site. The bulk of the energy generated by any current flaw is dissipated as heat by resistor bank 50 to 53, which is mounted on a thermally conductive backbone to further dissipate the heat to the surrounding environment.

As power is applied to the circuit 35 as above described, a diode 58 conducts and applies the DC voltage to the series connected Zener diodes 59, 60 and 62. The Zener diodes 59, 60 and 62 act to prevent voltages below approximately 150 VDC from being passed to the high voltage power supply module 32. A Zener diode 64 will conduct at a preselected voltage and prevent an overvoltage being applied as an output of the safety circuit module as an input to the high